

# Boosting the Development of OpenDRIVE through Integration Into Standardised GIS Frameworks

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Michael Scholz



Knowledge for Tomorrow



# German Aerospace Center (DLR)

Institute of Transportation Systems



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# German Aerospace Center



## Research institutes

- Aeronautics
- Space
- Energy
- Transportation
- Security
- Digitalisation

## Space administration

## Project management agency





# Institute of Transportation Systems

## Key facts

- In Berlin and Braunschweig
- Around 200 Employees

## Research fields

- Automotive
- Railway systems
- Traffic management
- Multi-modal and public transport

## Area of work

- Fundamental research
- Conception and strategy development
- Prototyping





# Our research infrastructure ...



## ... and our Testbed of Lower Saxony





# Road networks with OpenDRIVE

A high-resolution satellite image of the Earth, showing the curvature of the planet. The visible portion includes the Arctic region with a large white ice cap, surrounding blue oceans, and green landmasses of Northern Europe and Asia. The image is positioned in the lower right quadrant of the slide.

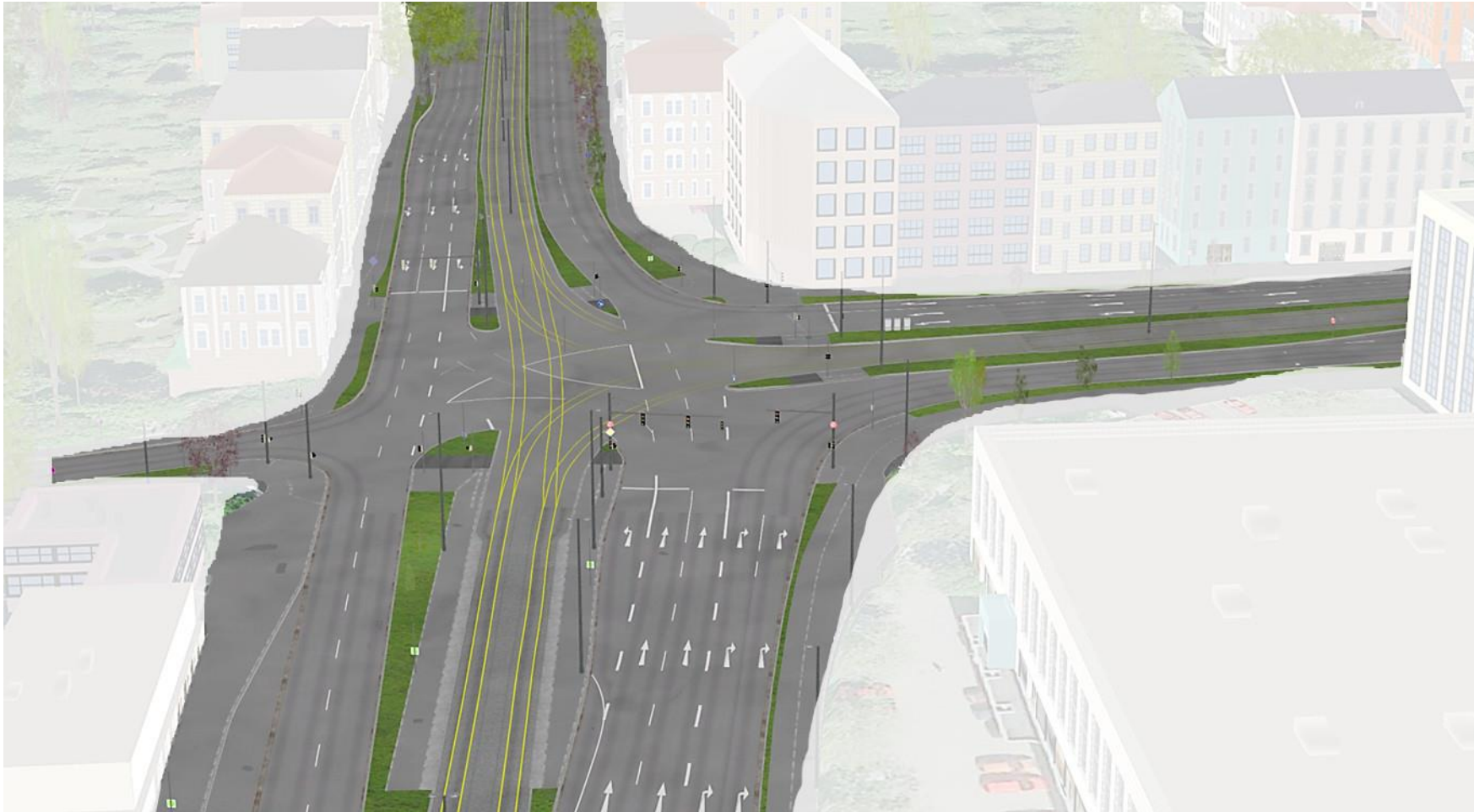
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# Fancy driving simulations ...

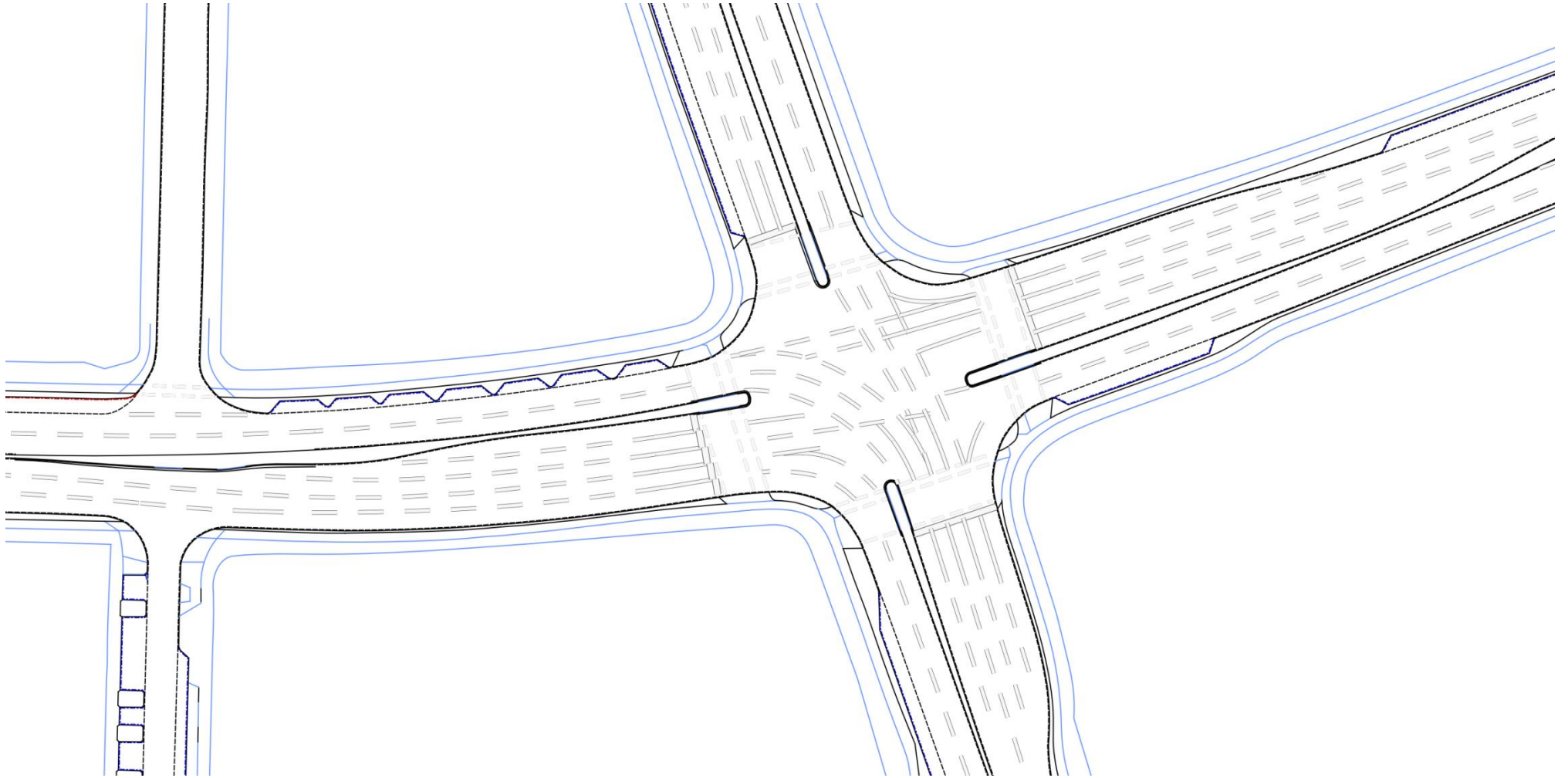




## ... require highly-detailed road network data



## ... require highly-detailed road network data





# OpenDRIVE?



# OpenDRIVE: open industry standard

- XML-based database
- Hierarchical structure

```

<road length="1000.0" id="0">
  <link>
    <successor elementType="road"
      elementId="1" contactPoint="start"/>
  </link>
  <type s="0.0" type="motorway"/>
  <planView>
    <geometry x="0.0" y="0.0" hdg="0.0"
      length="1000.0">
      <arc curvature="0.004"/>
    </geometry>
  </planView>
  <elevationProfile>
  </elevationProfile>
  <lateralProfile/>
  <lanes>
    <laneSection>
      <left>
        <lane id="7" type="border">
        </lane>
        <lane id="6" type="shoulder">
        </lane>
        <lane id="5" type="stop">
        </lane>
        <lane id="4" type="driving">
          <link>
            <successor id="4"/>
          </link>
          <width a="3.75"/>
          <roadMark type="solid" weight="bold"
            color="white" width="0.3">
            <type>
              <line length="1.0" space="0.0"
                width="0.3"/>
            </type>
          </roadMark>
        </lane>
      </left>
    </laneSection>
  </lanes>
</road>

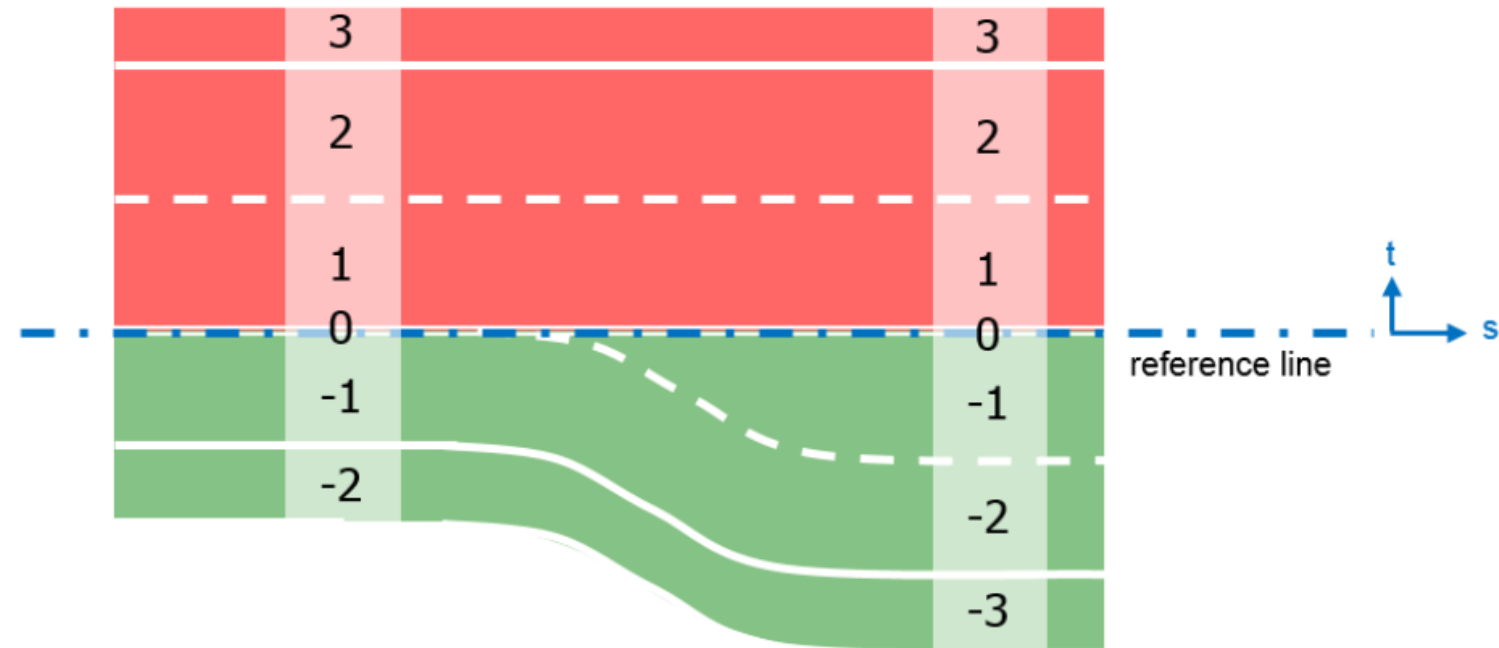
```





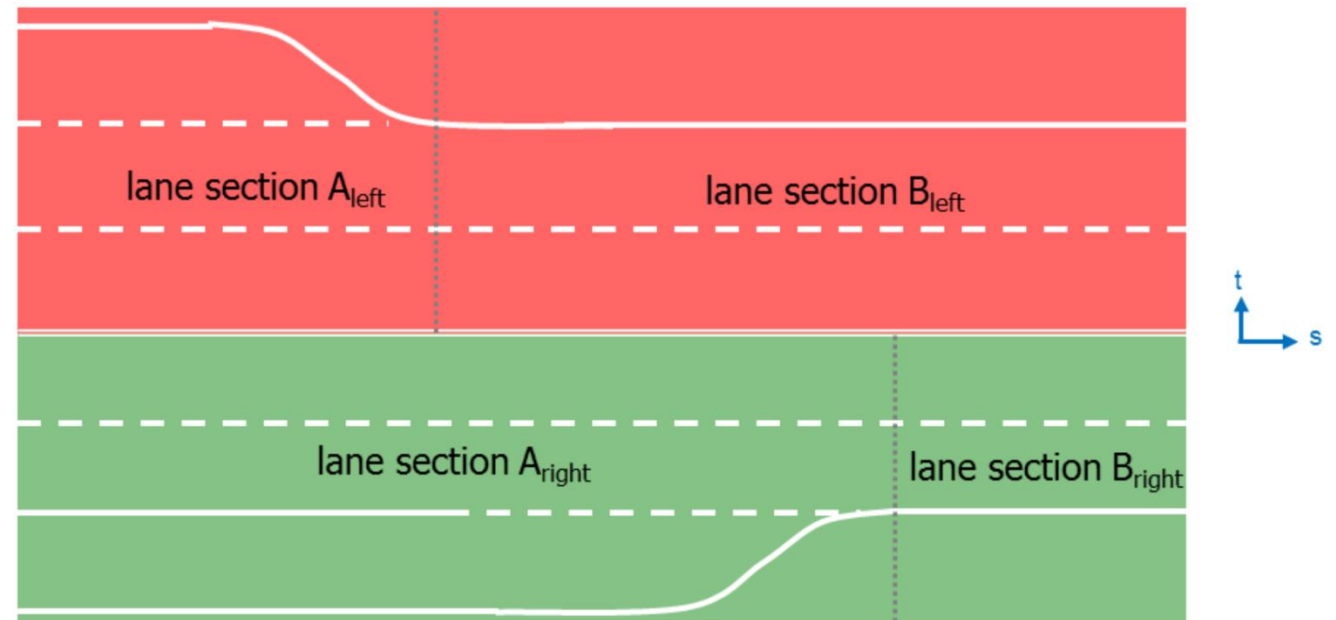
# OpenDRIVE: open industry standard

- XML-based database
- Hierarchical structure
- Detailed lane modelling



# OpenDRIVE: open industry standard

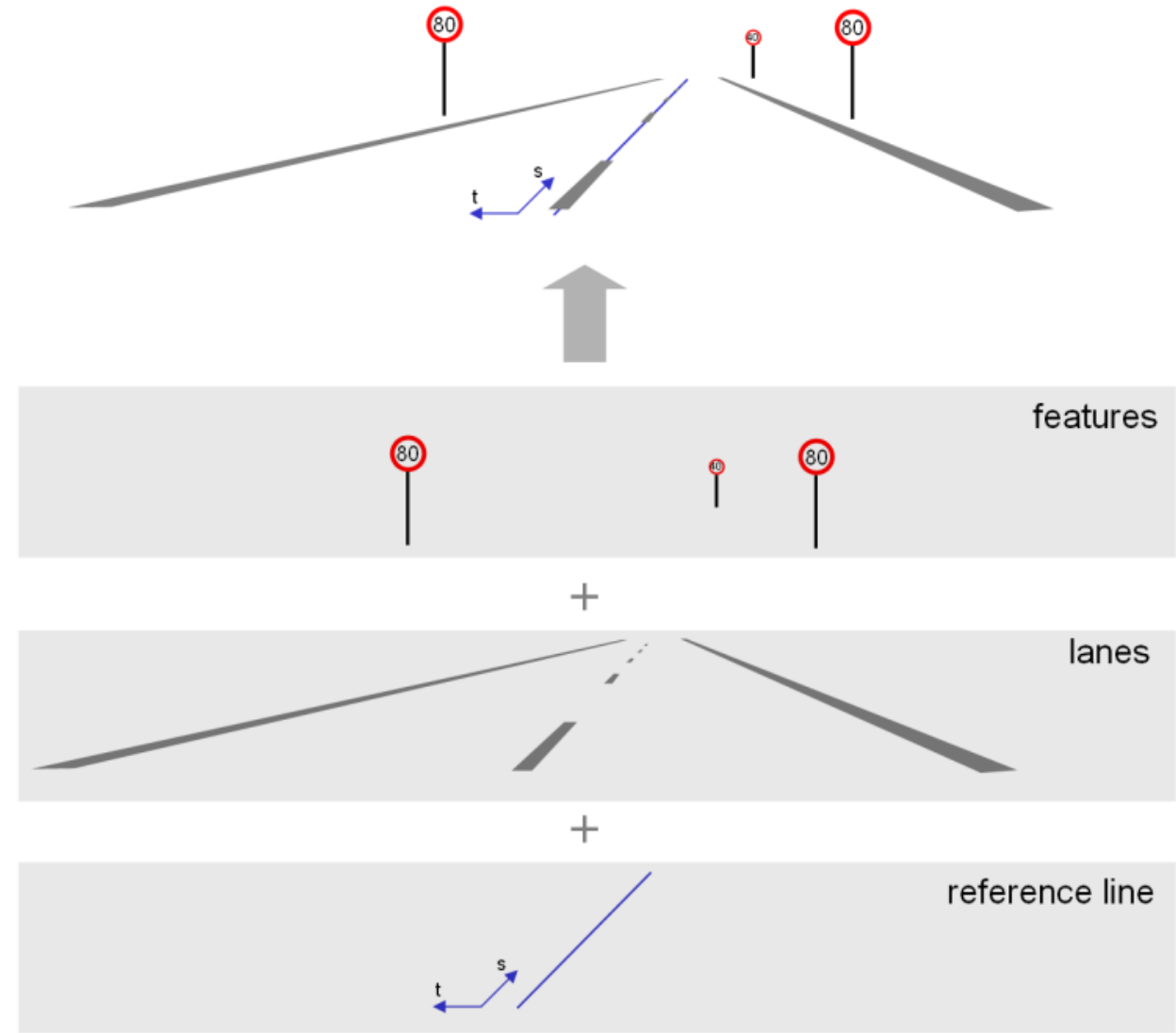
- XML-based database
- Hierarchical structure
- Detailed lane modelling





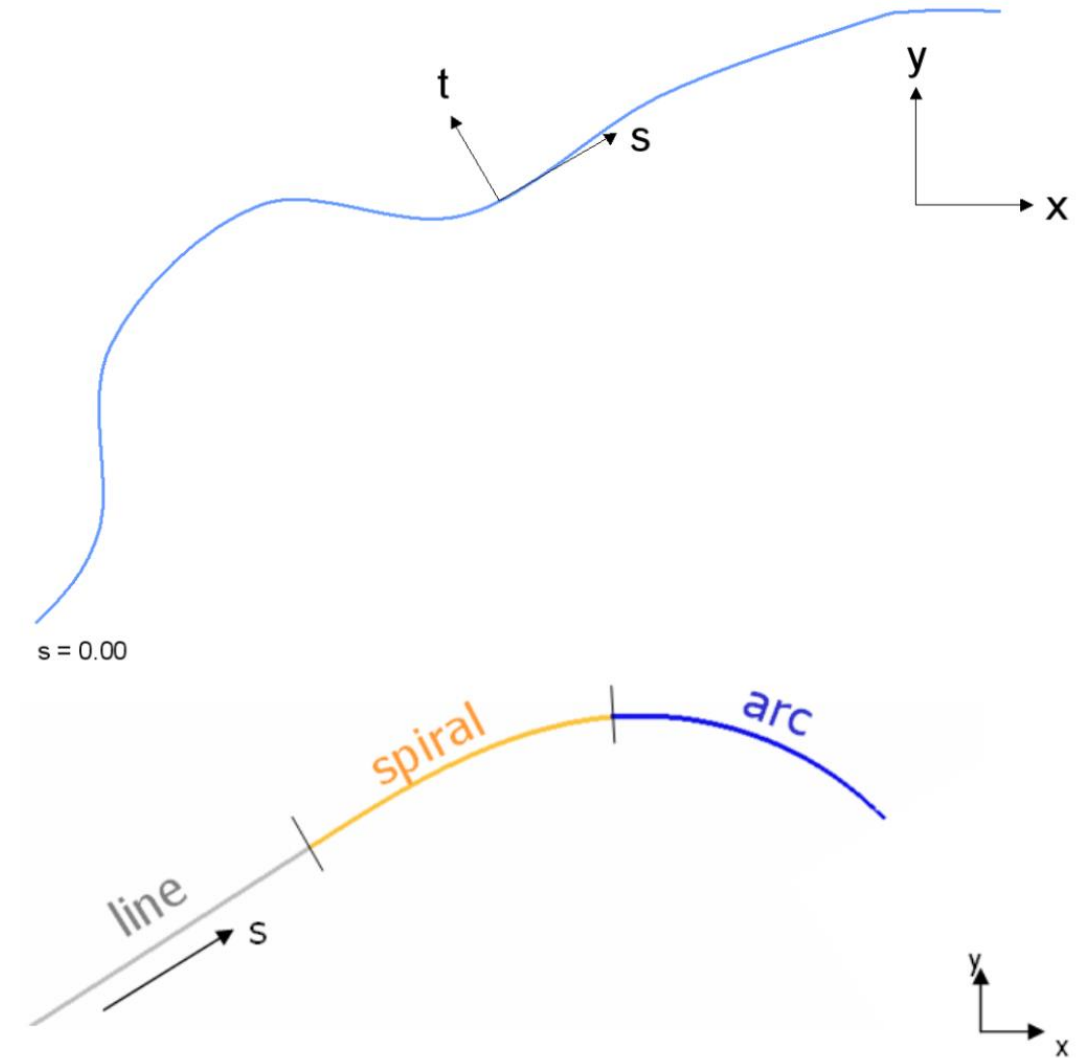
# OpenDRIVE: open industry standard

- XML-based database
- Hierarchical structure
- Detailed lane modelling
- Elements refer to an imaginary reference line



# OpenDRIVE: open industry standard

- XML-based database
- Hierarchical structure
- Detailed lane modelling
- Elements refer to an imaginary reference line
- Road topography (3D) und topology
  - continuous geometry definition





# OpenDRIVE: reference line geometry representation

```
| | speed  
| | -planView  
| | | -geometry  
| | | | -line  
| | | | -spiral  
| | | | -arc  
| | | | -poly3  
| | | | -paramPoly3  
| | -elevationProfile
```

OpenDRIVE Format Specification, Rev. 1.4



# OpenDRIVE: discrete geometry anchor points

```
<planView>  
  <geometry s="0.0" x="604944.1037"  
    y="5792860.1272"  
    hdg="3.5148"  
    length="9.7589">  
    <arc curvature="9.0884E-4"/>  
  </geometry>  
  <geometry s="9.7589" x="604935.03"  
    y="5792856.5285"  
    hdg="3.5237"  
    length="12.0">  
    <line/>  
  </geometry>  
</planView>
```



# OpenDRIVE: continuous geometry evolution

```
<planView>
  <geometry s="0.0" x="604944.1037"
    y="5792860.1272"
    hdg="3.5148"
    length="9.7589">
    <arc curvature="9.0884E-4"/>
  </geometry>
  <geometry s="9.7589" x="604935.03"
    y="5792856.5285"
    hdg="3.5237"
    length="12.0">
    <line/>
  </geometry>
</planView>
```





## Application-based discretization (sampling)

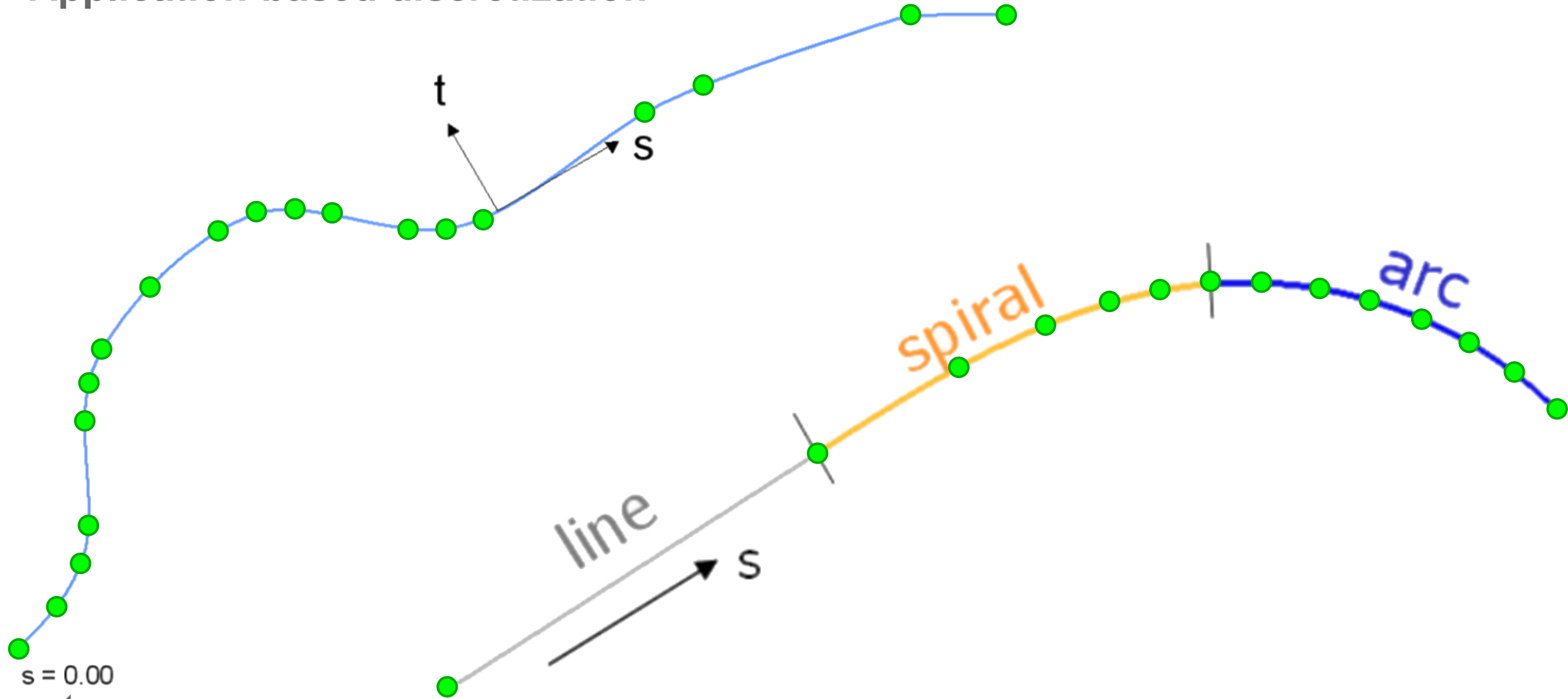
„Everyone is doing this!“



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# Application-based discretization



# OGC Simple Feature primitives



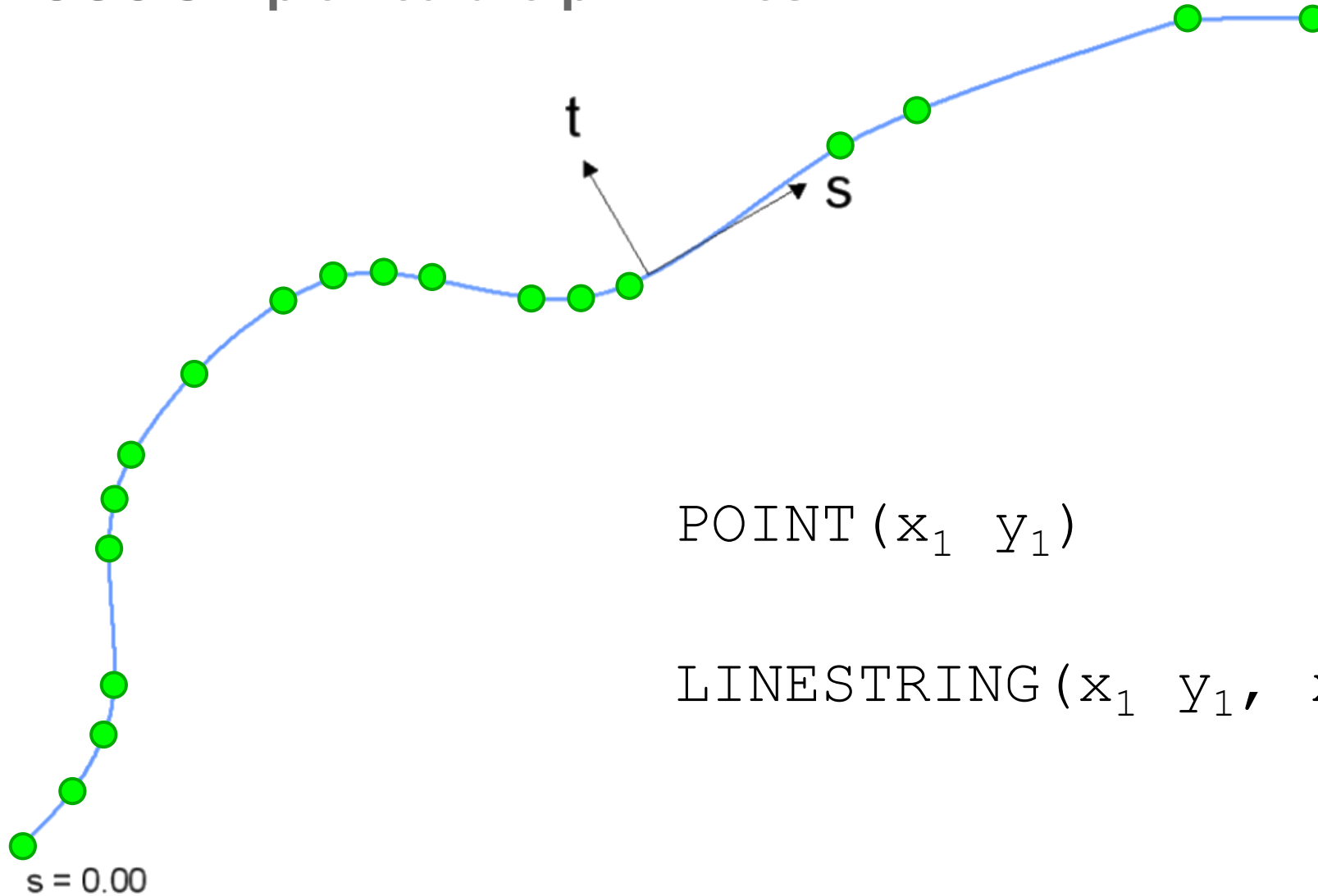
The screenshot shows the OGC website with the following elements:

- OGC Logo:** "OGC® Making location count."
- Navigation Menu:** About, Standards, Innovation, News & Events, Membership, Resources.
- Section Header:** Simple Feature Access - Part 1: Common Architecture
- Sub-headers:** 1) Downloads, 2) Related News
- Table:** A table listing document versions, titles, numbers, and types.
- OGC® Standards List:** A list of standards including 3D Tiles, 3dP, ARML2.0, Cat: ebRIM App Profile: Earth Observation Products, Catalogue Service, CDB, CityGML, Coordinate Transformation, Filter Encoding, GML in JPEG 2000, GeoAPI, GeoPackage, GeoSciML, GeoSPARQL, Geography Markup Language, GeoRSS, Geospatial eXtensible Access Control Markup Language (GeoXACML), and Geospatial User Feedback (GUF).

Version	Document Title (click to download)	Document #	Type
1.2.1	OpenGIS Implementation Specification for Geographic information - Simple feature access - Part 1: Common architecture	06-103r4	IS
1.2.0	OpenGIS Implementation Specification for Geographic information - Simple feature access - Part 1: Common architecture	06-103r3	D-IS
1.1.0	OpenGIS Implementation Specification for Geographic information - Simple feature access - Part 1: Common architecture	05-126	D-IS



## OGC Simple Feature primitives



POINT ( $x_1$   $y_1$ )

LINESTRING ( $x_1$   $y_1$ ,  $x_2$   $y_2$ , ...,  $x_n$   $y_n$ )



# Fitting OpenDRIVE into the Simple Feature model

```

<planView>
  <geometry s="0.0" x="604944.1037"
    y="5792860.1272"
    hdg="3.5148"
    length="9.7589">
    <arc curvature="9.0884E-4"/>
  </geometry>
  <geometry s="9.7589" x="604935.03"
    y="5792856.5285"
    hdg="3.5237"
    length="12.0">
    <line/>
  </geometry>
</planView>

```



```

LineString(
    604944.1037 5792860.1272,
    604752.81 5792819.10, ...)

LineString(
    604935.03 5792856.5285,
    604754.39 5792810.73, ...)

```



## *Live demo*

QGIS with OGC Simple Features and WMS/WFS



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## Conclusion: “Don’t re-invent the wheel”

- Geometry discretization could/should be based on OGC Simple Features
- Benefit from well-established tools in GIS domain:
  - Free/open frameworks for Java, C++, Python, ... and web development
  - Super-easy ad hoc combination with arbitrary geo-data
  - Direct conversion into 100+ other formats: KML, GML, GeoJSON, CSV, Shapefile, SQLite, XLSX, ...  
→ GDAL: “One library to rule them all”
  - Standardized web services already available (OGC WMS, WFS, ...)
- ASAM OpenDRIVE Area Concept Project introduces GIS aspects into OpenDRIVE



STADTBELEUCHTUNG 902945

Source: BS | Energy

x: 605 168.6  
y: 577 306.24  
r: 15  
(UTM)

<https://youtu.be/diEnlUT6HmA>

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LICHTSIGNALANLAGE 25139

Source: BELLIS

x: 605 162.71  
y: 577 297.43  
r: 15  
(UTM)

VORFAHRT 51236

Source: BELLIS

x: 605 156.88  
y: 577 298.07  
r: 30  
(UTM)

Fahrbahnmarkierung 85736A

Source: Mobile  
Mapping

x: 605 160.78  
y: 577 285.07  
r: 15  
(UTM)

GEBÄUDE 7267839

Source: Geoinformation  
Braunschweig

x: 605 153.39  
y: 577 302.98  
r: 0  
(UTM)

GELÄNDEMDELL

Source: Geoinformation Braunschweig